

show how the information given on the charts may be grouped for comparison. Obviously breadth from left to right in a figure denotes great temperature range while length from top to bottom shows uneven distribution of rainfall. New York shows its marked evenness of rainfall, as Tatoosh Island shows small range of temperature. Savannah's heavy July rainfall is easily recognized and irregularity of its figure with crisscrossing lines suggests cyclonic influences and perhaps the effect of local controls.

Four stations, Tatoosh Island, New York, Yankton, and Denver, in approximately the same latitude were chosen to show reading from right to left the decrease in marine influence and the increase in elevation above sea level (fig. 1, upper right).

Los Angeles, St. Louis, and Savannah in approximately the same latitudes (fig. 2, lower left) show clearly from left to right the typical Mediterranean type, the continental type and the littoral type in low middle latitudes.

These two climographs were plotted with dry-bulb readings and relative humidity.

Climograph (fig. 1, lower right) shows the average maximum temperatures (dry-bulb) for April, July, and October with the average depression of the wet-bulb from that maximum for the same months. A study of these figures shows a complete gradation from Tatoosh Island with its air showing the least drying power, if there were no wind, through Savannah, inclining, in summer toward the hot sticky type, to Phoenix with its hot, drying atmosphere.

In Figure 1, lower center is shown the result of an experiment to plot wind velocity with vapor pressure. The three stations, Phoenix, St. Louis, and Tatoosh show a difference in cooling power of the air based on these two factors. Perhaps this form of climograph may supplement the information given by the relative-humidity dry-bulb type of graph.

The construction of these graphs offers an opportunity for endless surmises and possibilities as to different combinations of factors. The study can not fail to stimulate clear thinking and promote intense interest in this phase of climatology.

DRY MONTHS IN THE UNITED STATES.

By ALFRED J. HENRY.

[Weather Bureau, Washington, D. C., October 28, 1922.]

The wide-spread and rather severe drought which prevailed during the month, as elsewhere noted in this Review leads the Editor to briefly summarize the meteorological conditions associated with prolonged dry weather. His previous studies of the subject¹ have shown that local droughts prevail in some part of the country in practically every year. General droughts, however, are not of such frequent occurrence and are less easily discussed in their true perspective. It would seem, however that they are due to changes in the pressure distribution over considerable portions of the continents and oceans which, in turn, lead to modifications in the general winds of the drought-affected regions.

The data used.—In this study the data used are the monthly departures from the normal precipitation for each climatic district as published in Table 1 of the MONTHLY WEATHER REVIEW. These data are available back to 1881, thus covering a span of 41 years. Table 1, with which readers of the REVIEW are familiar, contains in full-face type the mean temperature, mean precipitation and other data for the respective districts in the United States. The procedure was to tabulate the number of districts for each month of the period for which precipitation was above, below, or exactly equal to, the normal for the month in question, regardless of the amount of the abnormality. This method gives, therefore, qualitative results only.

Checking the qualitative against quantitative results shows good agreement; it is felt, therefore, that the method followed in the work has given worth-while results.

In the tabulation was given the percentage for each month of the period. These percentages may be considered as roughly indicating the percentage of the total area for which precipitation was exactly normal or above normal. The climatic districts are not of equal area, hence the results must be only an approximation.

If precipitation should be above normal in all of the 21 districts the percentage for that month would be of

course 100. The tabulation showed that the nearest approach to that figure was in December, 1884, when 95 per cent of the districts had precipitation above the normal. In but 8 of the 492 months in the entire period was the area of excess of precipitation as much as 80 per cent or more of the total. It may also be noted that the months of widely distributed normal rains occur mostly in the spring, never in the summer and autumn and rarely in winter. On the other hand there were four months during which precipitation was below normal in all districts, viz, January, 1902; March and December, 1910; and November 1917.

With the object of increasing our knowledge of the general weather conditions which prevail during dry weather in the United States the above-mentioned months have been considered separately and collectively.

DRY MONTHS.

Atmospheric pressure seems to be the one element that is definitely related to the amount and frequency of precipitation. The distribution of pressure is, however, conditioned upon the paths followed by traveling cyclones and anticyclones; inasmuch as the latter are not available for large portions of the globe, particularly in the Arctic region, the avenue of approach to the problem through the frequency of cyclones and anticyclones is shut off. Brooks and Glaspoole² have shown that droughts in the British Isles are associated with low pressure in the Arctic.

The same conclusion is apparent in this brief study. March, 1910, one of the months studied, was one of the driest of that name in the United States within a century. There was in that month a pronounced diminution in mean pressure in the neighborhood of Iceland and thence westward across the continent of North America and increased pressure over the British Isles and northern Europe. (See the statistics of *Reveau Mondial*, 1910.)

¹ Bulletin Q—Climatology of the United States pp. 51-58.

² Quart. Jour. XLVII, p. 139-166.

The mean temperature in the same month was largely in excess of the normal over the whole of the North American Continent from latitude 30° to near the Arctic Circle, and the same appears to hold for corresponding latitudes in Europe.

In the remaining dry months the deviation from the March, 1910, type was mostly in the occurrence of low mean pressure over the western part of the North Atlantic, as evidenced by the reports from the Canadian Maritime Provinces, just the opposite of March, 1910. In the United States pressure was high in the South and West in all of the months considered, thus indicating a preponderance of anticyclonic movement from the Northwest and West and naturally a deficient rainfall. The pressure type associated with deficient precipitation in the United States is conceived to be therefore low in the North and high in the South, or, in terms of anticyclonic movement, a drift to the southeast west of the Great Lakes. Concurrently therewith cyclones appear to move

along the northern circuit but without pronounced ridges of high pressure separating them, and thus pressure on the mean of the month is below the normal. The precipitation under such conditions is generally light.

For the current month pressure was in excess of the normal in the region of the Great Lakes and thence eastward to the Atlantic. (See inset on Chart I of this Review and also the paths of anticyclones on that chart.) The abnormality of temperature is shown on Chart III and that of precipitation by the inset on Chart IV. On the latter it may be seen that several small areas of precipitation above the normal appear, in some of which the contrast between rather closely situated stations, as for example, Washington and Baltimore, is pronounced. This is due in that instance, and perhaps in others, to the occurrence of a single intense rainfall at the beginning of the drought, a feature that has been previously noted; in other words, drought is at times ushered in by an exceptionally heavy fall of rain.

RECORDS OF TORNADES IN TENNESSEE, 1808-1921.

By ROSCOE NUNN, Meteorologist.

[Weather Bureau, Nashville, Tenn., September 2, 1922.]

A paper on the subject of tornadoes, especially those that have occurred in Tennessee, was given before the Tennessee Academy of Science, November 25, 1921. For that paper the records of tornadoes in Tennessee for the period 1889-1921, only, were used, the data for these years being considered as more complete than for the earlier years. But it may be well to include all available records in the present discussion, and mention will therefore be made of the data collected and studied by Lieut. John P. Finley, of the Signal Corps, which cover the period 1808-1888.

It should be borne in mind that tornado statistics for the earliest years of record must necessarily be incomplete. Even at the present time a tornado may occur without being recorded. Tornadoes always have narrow paths and frequently the path is only a few miles in length. It is therefore conceivable that even now, when the population is much more dense than it was 100 or even 50, years ago, a tornado might strike a thinly populated area and escape notice, or, at least, fail to be placed on record.

Prior to 1871 the records for Tennessee are very scattering and doubtless incomplete, for Finley was able to report only nine tornadoes for the period 1808-1870; and of these nine there were three in the year 1830. Beginning about 1871, when the old Signal Corps (predecessor of the Weather Bureau) began its meteorological work, tornado records are much more complete, as indicated by Finley's statistics, which show 9 tornadoes for the period 1871-1878 and 23 for the 10-year period of 1879-1888.

An average annual frequency obtained from Finley's data for the period 1871-1888 is slightly greater than the average obtained from the data for the period 1889-1921. If we combine the two periods, making one period of 51 years, with 79 tornadoes, we get an average frequency of 1.5 tornadoes per year in Tennessee, which is probably very nearly correct. This is a low frequency as compared with the frequency in the principal tornado regions; for example, the annual average frequency for Kansas is 8.8. (See article by S. P. Peterson in the MONTHLY WEATHER REVIEW for May, 1922.)

Tornadoes occur more frequently in the spring than any other part of the year. In Tennessee during the last 33 years April has a greater number of tornado dates than

any other month, viz., 6; then comes March, with 5, May with 4, January with 2, and February, July, August, September, October, November, and December with 1 each; while June has no tornado accredited to it during these years. On some occasions as many as 4 different tornadoes occurred almost simultaneously, traveling in nearly parallel paths; so that, with a total of 24 different dates for the last 33 years, we have a total of 47 tornadoes.

There is no regularity whatever in the occurrence of tornadoes. There were none in 1896, 1897, and 1898, and only one in 1899, but in 1900 came the very unusual visitation of November 20, when 39 people were killed and much property destroyed, principally at Columbia. There was a remarkable absence of tornadoes in the State during the period 1901-1908; but this was followed by that most memorable tornado year, 1909, with four destructive storms on April 29, killing 60 people in the State, and three storms on October 14, killing 9 people. The years 1910, 1911, and 1912, were free from tornadoes, but in 1913 there were four, all on March 13, causing 21 deaths. The years 1914 and 1918 were without tornadoes in this State, but they were frequent in 1917, 1920, and 1921, though not very destructive. In 1921 the frequency with which they occurred in Maury, Marshall, and Bedford Counties was quite notable.

The geographical distribution of tornadoes in Tennessee is shown in figure 1A. As indicated by the arrows, a large majority of them move toward the northeast. The eastern half of the State, which is elevated and mountainous, has very few tornadoes, and if one occurs its path is quite short.

The Highland Rim of middle Tennessee doubtless has some effect in the way of weakening or breaking up tornadoes that originate in Mississippi and Alabama and move northeastward, but they frequently go over the highlands and move across the Central Basin. They also originate within the Central Basin. No tornado of much consequence has struck Nashville, but the storm of February 12, 1880, was probably a light tornado. It passed over the city about midnight and damaged the Federal Building, according to the report, "moving several blocks of granite and tearing down a gable end."